

## Newly recorded species of *Pinnularia* (Bacillariophyta) in China

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**Abstract** Five species and three varieties of *Pinnularia* (Bacillariophyta) are first reported in China. They are *Pinnularia borealis* var. *subislandica* Krammer, *P. divergentissima* var. *subrostrata* Cleve-Euler, *P. episcopalis* Cleve, *P. erratica* Krammer, *P. esoxiformis* Fusey, *P. spitsbergensis* Cleve, *P. undula* (Schumann) Krammer, and *P. undula* var. *mesoleptiformis* Krammer. All were collected from Da'erbin Lake and marshes around it in the Da Hinggan Ling Mountains, Nei Mongol Autonomous Region, China. These species were observed with LM and SEM and their taxonomic characters and habitats are discussed.

**Key words** *Pinnularia*, new records, China.

Marshes are the areas with high algal diversity. The Da Hinggan Ling Mountains, located in northeast of China, have the large areas of wetlands. Diatoms were collected and investigated from wetlands near Axshan in the southwestern region of the Da Hinggan Ling Mountains in August 2004 and August and October 2005. Based on our identification of diatoms collected, five species and three varieties of *Pinnularia* (Bacillariophyta) are first reported from China here.

### 1 Material and methods

The samples were collected from Axshan (Da Hinggan Ling Mountains), northeastern Nei Mongol Autonomous Region, China. The sample sites are Da'erbin Lake and swamps around it. Detailed information concerning the samples and precise collection localities is given in Table 1.

Formalin (4%) was added immediately to fix the samples in the field. All samples were treated with concentrated oxidative acids (Guo, 1999; Zhu & Chen, 2000; Chen, 2006). For light microscopy, samples were mounted in "Kanadabalsam duktil optisch rein" on coverslips and examined by Nikon E800 (LM 1000) and were photographed using a Nikon DXM1200 digital camera (You, 2005; Liu, 2006). For SEM observation cleaned samples were mounted on stubs sputter-coated with gold and observed under JEOL JSM-6380LV scanning electron microscope (SEM). Identifications are based on publications by Cleve-Euler (1955), Hustedt (1930), Krammer (1992, 2000), and Krammer and Lange-Bertalot (1997).

### 2 Description of species

**1. *Pinnularia borealis* var. *subislandica* Krammer in Lange-Bertalot, Diatoms of Europe 1: 25, fig. 8: 1–5. 2000.**

北方羽纹藻近岛变种 Figs. 1–4

Valves linear and linear-elliptical, margins parallel to moderately convex, ends truncate; length 26–50  $\mu\text{m}$ , breadth 8–11.5  $\mu\text{m}$ , 4–5 striae/10  $\mu\text{m}$ . In the SEM, there are 11–13 rows of puncta in each stria.

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**Table 1** List of sample numbers, collect date and habitat characteristic

No. of sample	Date	Habitat	Altitude (m)	pH	Collector
043132	Aug. 2004	Swamp around the lake	1295	4.7	Q. X. Wang et al.
043134	Aug. 2004	Swamp around the lake	1310	5.4	Q. X. Wang et al.
043135	Aug. 2004	Swamp around the lake	1310	4.7	Q. X. Wang et al.
043136	Aug. 2004	Swamp around the lake	1310	5.6	Q. X. Wang et al.
043137	Aug. 2004	Swamp around the lake	1310	5.6	Q. X. Wang et al.
043138	Aug. 2004	Swamp around the lake	1310	6.4	Q. X. Wang et al.
043139	Aug. 2004	Swamp around the lake	1310	6.5	Q. X. Wang et al.
053127	Aug. 2005	Benthic on plants in the lakeside	1305	7.7	Q. X. Wang et al.
053130	Aug. 2005	Benthic on plants in the lakeside	1305	7.3	Q. X. Wang et al.
053133	Aug. 2005	Planktonic in the lake	1298	8.9	Q. X. Wang et al.
053135	Aug. 2005	Planktonic in the lake	1298	8.9	Q. X. Wang et al.
053136	Aug. 2005	Planktonic in the lake	1298	8.9	Q. X. Wang et al.
053137	Aug. 2005	Benthic on plants in the lakeside	1298	8.9	Q. X. Wang et al.
053139	Aug. 2005	Benthic on plants in the lakeside	1298	8.6	Q. X. Wang et al.
053150	Aug. 2005	Swamp around the lake	1298	4.3	Q. X. Wang et al.
053151	Aug. 2005	Swamp around the lake	1298	4.8	Q. X. Wang et al.
053152	Aug. 2005	Swamp around the lake	1298	4.7	Q. X. Wang et al.
053153	Aug. 2005	Swamp around the lake	1298	4.3	Q. X. Wang et al.
053154	Aug. 2005	Swamp around the lake	1298	4.8	Q. X. Wang et al.
053155	Aug. 2005	Swamp around the lake	1298	4.3	Q. X. Wang et al.
053156	Aug. 2005	Swamp around the lake	1298	5.0	Q. X. Wang et al.
053319	Oct. 2005	Benthic on plants in the lakeside	1288	8.0	J. G. Cao et al.
053321	Oct. 2005	Benthic on plants in the lakeside	1288	8.0	J. G. Cao et al.
053322	Oct. 2005	Swamp around the lake	1288	4.5	J. G. Cao et al.
053323	Oct. 2005	Swamp around the lake	1288	4.5	J. G. Cao et al.
053327	Oct. 2005	Benthic on plants in the lakeside	1288	7.8	J. G. Cao et al.
053329	Oct. 2005	Planktonic in the lake	1288	7.7	J. G. Cao et al.
053332	Oct. 2005	Swamp around the lake	1288	4.5	J. G. Cao et al.
053333	Oct. 2005	Swamp around the lake	1288	4.5	J. G. Cao et al.
053334	Oct. 2005	Swamp around the lake	1288	4.5	J. G. Cao et al.
053335	Oct. 2005	Swamp around the lake	1288	4.5	J. G. Cao et al.

Sample numbers: 043134, 043135, 043138, 043139, 053135, 053153, 053155, 053332, 053334.

Previously known distribution: Europe, Subarctic region.

Compared with *P. borealis* Ehrenb., the present variety tends to have larger frustules, more truncate ends and fewer striae per 10  $\mu\text{m}$ . But this variety is smaller than *P. borealis* var. *islandica* Krammer. Our specimens are smaller than the described form.

**2. *Pinnularia divergentissima* var. *subrostrata*** Cleve-Euler, 10, fig. 1: 5. 1898; Krammer in Lange-Bertalot, Diatoms of Europe 1: 44, figs. 11: 11–17, 60: 6. 2000.

极歧纹羽纹藻近喙头变种 Figs. 5–7

Valves linear to linear-lanceolate, sides weakly convex, ends broadly capitate; length 27–33  $\mu\text{m}$ , breadth 5.4–6.7  $\mu\text{m}$ . Raphe branches commonly straight, axial area narrow. Striae extremely divergent with a sudden change in direction halfway to the ends, strongly radiate towards the valve centre, strongly convergent towards the ends, with an acute angle being formed between the two striae groups where they meet, 12–15 striae/10  $\mu\text{m}$ .

Sample numbers: 043132, 043134, 043135, 043136, 043137, 053150, 053151, 053153, 053322, 053333, 053334, 053335.

Previously known distribution: North Europe, Subarctic region.

Krammer (1992) described the variety *martinii*, which is now treated as a synonym of var. *subrostrata* (Krammer, 2000). Diagnostic characters are the strongly divergent striae and the broadly capitate ends which are the only differences with the nominate variety.

**3. *Pinnularia episcopalis*** P. T. Cleve in The Diatoms of Finland, Acta Soc. Fauna Flora

Fennica 8: 27, fig. 14. 1891; Krammer in Lange-Bertalot, Diatoms of Europe 1: 66, figs. 41: 6, 42: 1–6, 43: 1, 2. 2000.

巨大羽纹藻 Figs. 20, 21

Valves outline linear with parallel sides, ends not differentiated and broadly rounded or broadly keel-like rounded; length 100–190  $\mu\text{m}$ , breadth 25–40  $\mu\text{m}$ . Axial area linear, usually 1/3 of the valve breadth, sometimes the central area with irregular arranged structures. Striae 5–7/10  $\mu\text{m}$ , radiate in the middle, moderately convergent at the ends.

Sample numbers: 043132, 043134, 043136, 043137, 053322.

Previously known distribution: Europe, North America.

This species is often cosmopolitan, rare, epipellic in oligotrophic mountain water with low electrolyte content, pH lower than 6, frequent in fossil samples. It is similar to *P. novaezealandica* Krammer, which is distinguished by the cuneate ends and broad longitudinal bands (Krammer, 2000). Our samples were collected from the swamps around the lake, with pH 4.5–5.6. Krammer (2000) described two morphotypes of this species. Morphotype 1 has broadly rounded valve ends; morphotype 2 has more acutely rounded valve ends. Our samples belong to morphotype 2. They are also very similar with *P. schweinfurthii* (A. S.) Patrick. (Yang, 1995), but the latter has more striae and size; its reported size range is 190–250  $\mu\text{m}$  long, 27–37.5  $\mu\text{m}$  wide. The most distinct differences are that *P. episcopalis* has lunate structures in the central area and is obviously larger than the specimens from China.

**4. *Pinnularia erratica*** Krammer in Lange-Bertalot, Diatoms of Europe 1: 96, fig. 73: 2–8. 2000.

不定羽纹藻 Figs. 11, 12

Valves outline rhombic-lanceolate to elliptical, sides weakly convex, ends broadly capitate swollen; length 62–90  $\mu\text{m}$ , breadth 9–12  $\mu\text{m}$ , length-to-breadth ratio about 5. Axial area 1/5–1/3 the valve breadth, linear, with 9–11 striae/10  $\mu\text{m}$ , strongly radiate in the middle, strongly convergent towards the ends. There are only two large or occasionally a few irregularly arranged markings on each side of the central nodule.

Sample numbers: 043135, 043139, 053150, 053151, 053152, 053153, 053154, 053155, 053156, 053322, 053329, 053332, 053334.

Previously known distribution: North Europe.

**5. *Pinnularia esoxiformis*** P. Fusey in Bull. Micr. Appliquée, 2e ser., 1/2: 31–50, fig. 2: 41. 1951; Krammer in Lange-Bertalot, Diatoms of Europe 1: 157, figs. 141: 1–6, 146: 1–6. 2000.

狗鱼形羽纹藻 Figs. 8–10

Valve outline linear, sides parallel, ends cuneiformly rounded; length 67–91  $\mu\text{m}$ , breadth 11–13  $\mu\text{m}$ , length-to-breadth ratio 4.8–7.6. Raphe proximally laterally bent, central pores large, drop shaped, axial area broad 1/3 to more than 1/2 the breadth of the valve, linear, 7–10 striae/10  $\mu\text{m}$ , slightly radiate in the middle, parallel to convergent towards the ends.

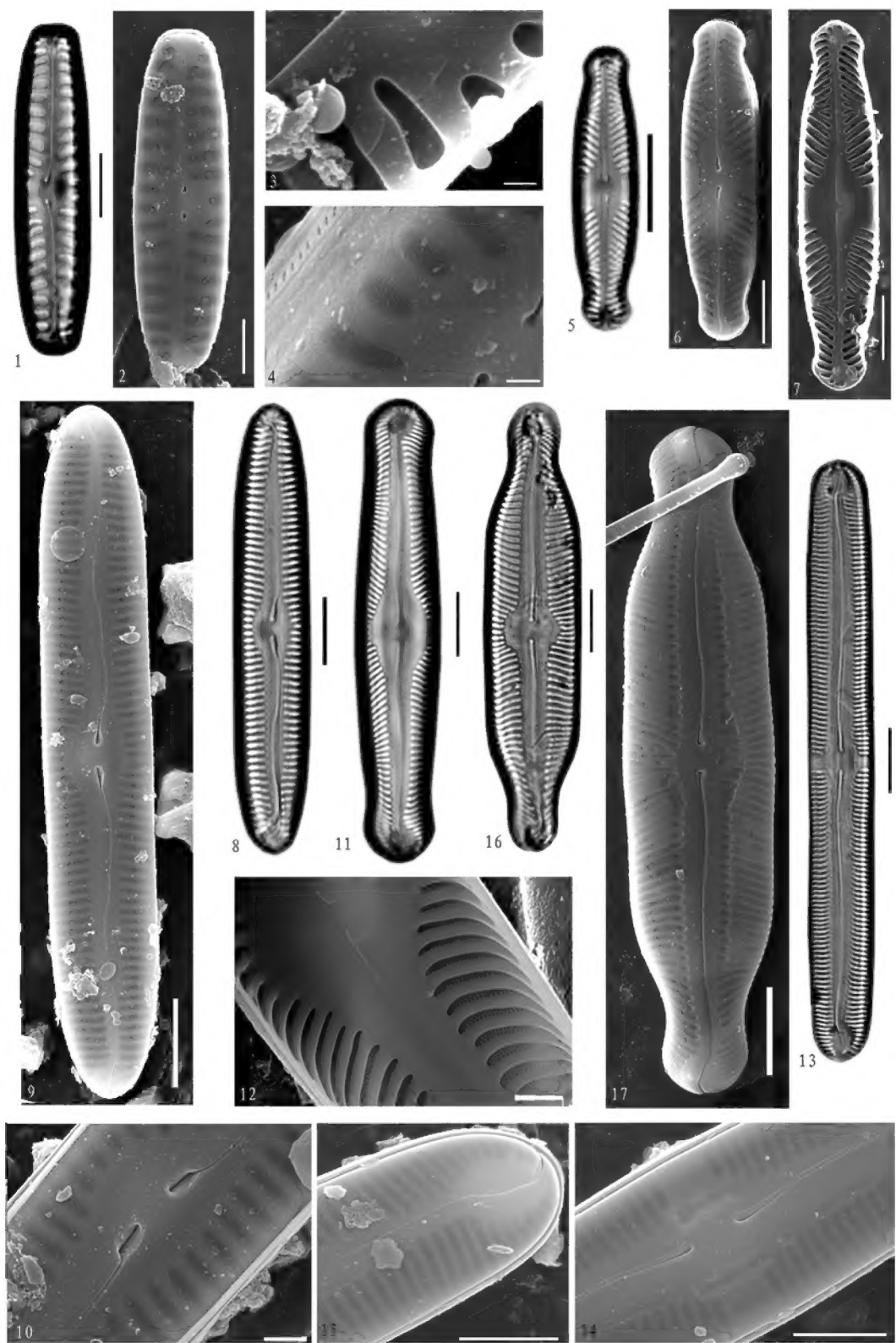
Sample numbers: 043132, 043134, 043135, 043136, 053130, 053136, 053137, 053139, 053150, 053151, 053153, 053155, 053322, 053323, 053332, 053333, 053334, 053335.

Previously known distribution: Europe.

This species is distinguished by outline, raphe structure, and arrangement of the striae.

**Figs. 1–4.** *Pinnularia borealis* var. *subislandica* Krammer. **1.** External valve (LM). **2.** External valve (SEM). **3.** Internal valve (SEM), view of punctum. **4.** External valve (SEM), view of punctum. **Figs. 5–7.** *Pinnularia divergentissima* var. *subrostrata* Cleve-Euler. **5.** External valve (LM). **6.** External valve (SEM). **7.** Internal valve (SEM). **Figs. 8–10.** *Pinnularia esoxiformis* Fusey. **8.** External valve (LM). **9.** External valve (SEM). **10.** External valve, view of central area (SEM). **Figs. 11, 12.** *Pinnularia erratica* Krammer. **11.** External valve (LM). **12.** Internal valve (SEM). **Figs. 13–15.** *Pinnularia spitsbergensis* Cleve. **13.** External valve (LM). **14.** External valve, view of central area (SEM). **15.** External valve, view of terminal raphe endings (SEM). **Figs. 16, 17.** *Pinnularia undula* (Schumann) Krammer. **16.** External valve (LM). **17.** External valve (SEM).

Scale bar: 1, 5, 8, 9, 11, 13, 16, 17, 10  $\mu\text{m}$ ; 2, 6, 7, 15, 5  $\mu\text{m}$ ; 3, 4, 14, 1  $\mu\text{m}$ ; 10, 12, 2  $\mu\text{m}$ .



*P. notabilis* Krammer has more striae/10  $\mu\text{m}$ , and its outline is elliptic-lanceolate (Krammer, 2000). *P. peracuminata* Krammer is similar to the present species, but is much smaller, has a much narrower axial area, and its central raphe pores are less drop shaped. The central pores of *P. esoxiformis* are larger and clearly visible under the SEM (Pl. I: 10).

**6. *Pinnularia spitsbergensis*** P. T. Cleve in K. Svenska Vet. Akad. Handl. 27: 82, fig. 1: 13. 1985; Krammer in Lange-Bertalot, Diatoms of Europe 1: 144, figs. 121a: 10, 122: 1–5. 2000.

斯匹次羽纹藻 Figs. 13–15

Outline linear, sides parallel, ends broadly to cuneately rounded; length 75–96  $\mu\text{m}$ , breadth 9.5–11  $\mu\text{m}$ , length-to-breadth ratio 6.3–9.5. Axial area is 1/3 the breadth of the valve, linear, tapering at the ends. On either side of the central nodule in the central area are crescent-shaped markings, sometimes invisible or absent, under the SEM, they are two rows of irregular concave structures, 14–15 striae/10  $\mu\text{m}$ , parallel in the middle.

Sample numbers: 043132, 043133, 043134, 043136, 043137, 043139, 053127, 053136, 053139, 053150, 053151, 053153, 053155, 053156, 053321, 053322, 053323, 053332, 053333, 053334, 053335.

Previously known distribution: Europe.

This species is distinguished from *P. crucifera* Cleve-Euler by the combination of breadth, central area, terminal fissures, and the number of striae/10  $\mu\text{m}$ . There is considerable variation in morphological detail of the central area (Krammer, 2000). *P. stomatophora* (Grun.) Krammer is also similar to *P. spitsbergensis*. Under the SEM, both have the irregular concave structures in the central area, but the former has an elongate-elliptic to rhombic central area and striae moderately radiate in the middle, strongly convergent at the ends, 11–14/10  $\mu\text{m}$ . In our specimens striae are parallel throughout the entire length of the valves.

**7. *Pinnularia undula*** (Schumann) Krammer in Lange-Bertalot, Diatoms of Europe 1: 122, fig. 92: 3–12, 93: 1–4. 2000.

*Navicula undula* Schumann 1862, Schriften königl. physikalisch-ökonom. Gesellschaft Königsberg 3: 188, fig. 9: 37 (Fig. 92: 3).

波曲羽纹藻 Figs. 16–19

Valves linear, sides parallel to more or less triundulate; length 64–77  $\mu\text{m}$ , breadth 15–17  $\mu\text{m}$ . Raphe lateral, outer fissure weakly curved, axial area 1/5–1/3 the valve breadth, linear or slightly widening from the poles towards the middle, central area large, round, often commonly reaching the valve margin and distinct from the axial area, often irregularly ornamented with flecks, 8–10 striae/10  $\mu\text{m}$ , moderately to strongly radiate in the middle, strongly convergent at the ends. Under the SEM, 4–5 rows of puncta are visible in each stria (Pl. II: 1–2).

Sample numbers: 053319, 053327.

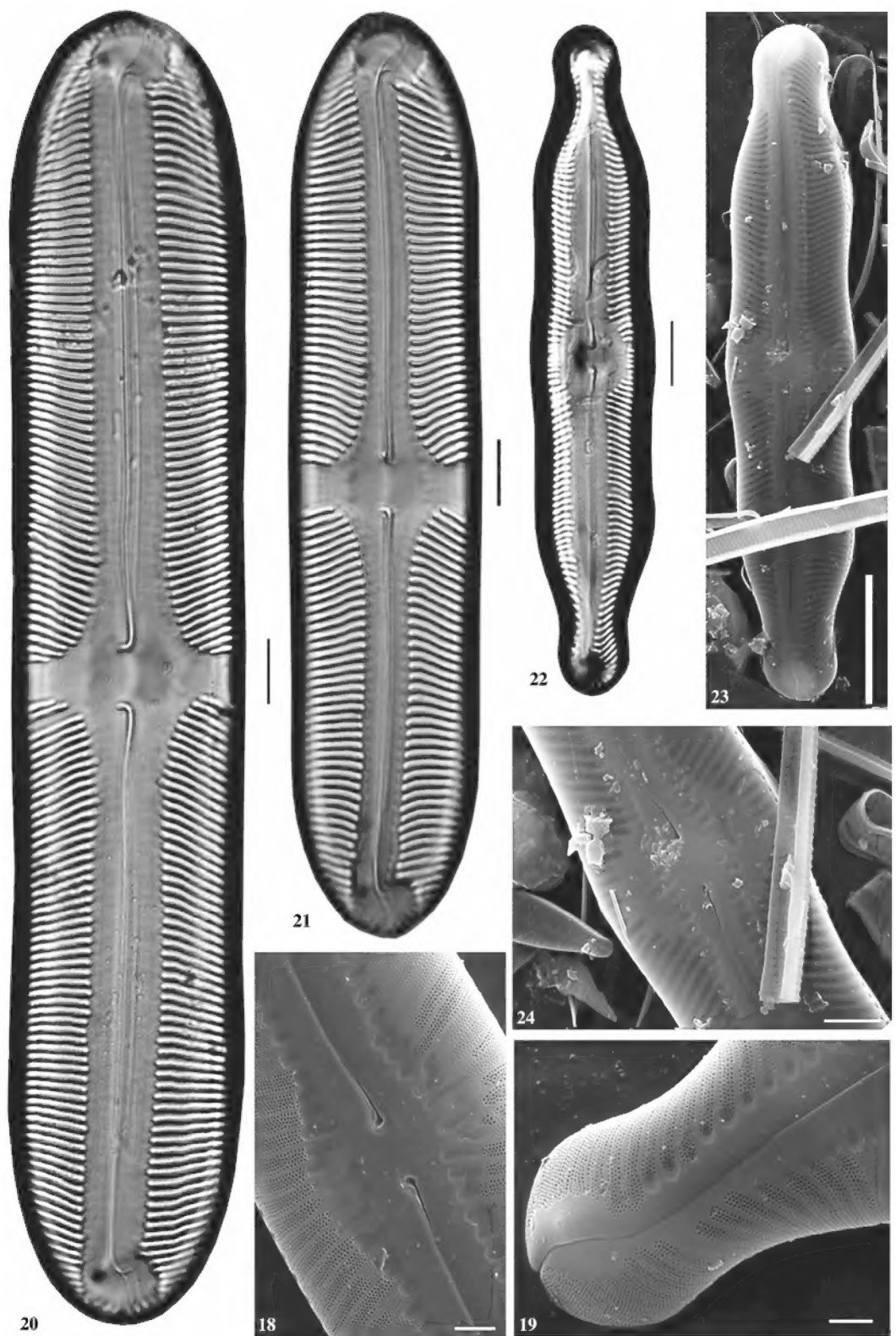
Previously known distribution: Europe, North America.

This species is very similar to *P. subdivergens* Krammer, but the latter has narrower valves and the sides of valve are weakly convex or indistinctly undulate. It also trends to have more striae in 10  $\mu\text{m}$ , a wider axial area, and weakly defined crescent-shaped markings in the central area.

**8. *Pinnularia undula* var. *mesoleptiformis*** Krammer in Lange-Bertalot, Diatoms of Europe

**Figs. 18, 19.** *Pinnularia undula* (Schumann) Krammer. **18.** External valve, view of central nodule (SEM). **19.** External valve, view of polar nodule (SEM). **Figs. 20, 21.** *Pinnularia episcopalis* Cleve, External valve (LM). **Figs. 22–24.** *Pinnularia undula* var. *mesoleptiformis* Krammer. **22.** External valve (LM). **23.** External valve (SEM). **24.** External valve, view of central area (SEM).

Scale bar: 18, 19, 2  $\mu\text{m}$ ; 20–22, 10  $\mu\text{m}$ ; 23, 20  $\mu\text{m}$ ; 24, 5  $\mu\text{m}$ .





1: 123, fig. 93: 1. 2000.

波曲羽纹藻中狭变种 Figs. 22–24

Valve sides strongly undulate, the inflations are equal in breadth or the central inflation is slightly broader than the other two; length 104–106  $\mu\text{m}$ , breadth 18–19.5  $\mu\text{m}$ , 9–10 striae/10  $\mu\text{m}$ .

Sample numbers: 053133.

Previously known distribution: Europe, North America.

This species is a new variety described by Krammer (2000). It is larger than the nominate variety, strongly triundulate sides and less striae in 10  $\mu\text{m}$ . Under the SEM, the central pores are slightly expanded. The central area is large and has two rows of irregular concave structures. *P. undula* var. *major* (A. Schmidt) Krammer is also similar to this variety, but its breadth is 20–22  $\mu\text{m}$  and its valves are triundulate. The central inflation is also narrower than the other two. Our samples are a little broader than the described form.

### References

- Chen C-P (陈长平), Gao Y-H (高亚辉), Lin P (林鹏). 2006. Four newly recorded species of Bacillariophyta from the mangroves in China. *Acta Phytotaxonomica Sinica* (植物分类学报) 44: 95–99.
- Cleve-Euler A. 1955. Die diatomeen von schweden und finnland. Kungl Svenska Vetenskaps-Akademiens Handlingar 5 (4): 1–232 (Teil IV: Biraphideae II).
- Guo J (郭健), Liu S-C (刘师成), Lin J-H (林加涵). 1999. Five newly-recorded species in the genus *Nitzschia* from China. *Acta Phytotaxonomica Sinica* (植物分类学报) 37: 526–528.
- Hustedt F. 1930. Die Süßwasser Flora Mitteleuropas. Heft 10: Bacillariophyta (Diatomeae). Jena: Gustav Fischer. 1–466.
- Krammer K. 1992. *Pinnularia*, eine Monographie der europäischen Taxa. *Bibliotheca Diatomologica* 26: 1–353.
- Krammer K. 2000. Diatom of Europe. Vol. 1: The Genus *Pinnularia*. Königstein: A. R. G. Gantner Verlag Kommanditgesellschaft. 1–703.
- Krammer K, Lange-Bertalot H. 1997. Bacillariophyceae, Teil1: Naviculaceae. In: Ettl H, Gerloff J, Heyning H, Mollenhauer D eds. Süßwasserflora von Mitteleuropa (Begründet von A. Pascher). Nachdr. Heidelberg: Spektrum Akademischer Verlag. 2(1): 1–876.
- Liu Y (刘妍), You Q-M (尤庆敏), Wang Q-X (王全喜). 2006. Freshwater diatoms from Kinmen Island in Fujian, China. *Journal of Wuhan Botanical Research* (武汉植物学研究) 24: 38–46.
- Yang J-G (杨积高). 1995. Some new records of Bacillariophyta in China. *Bulletin of Botanical Research* (植物研究) 15: 335–337.
- You Q-M (尤庆敏), Li H-L (李海玲), Wang Q-X (王全喜). 2005. Preliminary studies on diatoms from Kanasi in Xinjiang Uighur Autonomous. *Journal of Wuhan Botanical Research* (武汉植物学研究) 23: 247–256.
- Zhu H-Z (朱惠忠), Chen J-Y (陈嘉佑). 2000. Bacillariophyta of the Xizang Plateau (中国西藏硅藻). Beijing: Science Press. 1–353.

## 中国羽纹藻属(硅藻门)的新记录植物

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**摘要** 报道了采自大兴安岭达尔滨湖及其周围沼泽水体的硅藻门Bacillariophyta羽纹藻属*Pinnularia*中国新记录植物5种3变种, 分别为北方羽纹藻近岛变种*P. borealis* var. *subislandica* Krammer、极歧纹羽纹藻近喙头变种*P. divergentissima* var. *subrostrata* Cleve-Euler、巨大羽纹藻*P. episcopalis* Cleve、不定羽纹藻*P. erratica* Krammer、狗鱼形羽纹藻*P. esoxiformis* Fusey、斯匹次羽纹藻*P. spitsbergensis* Cleve、波曲羽纹藻*P. undula* (Schumann) Krammer和波曲羽纹藻中狭变种*P. undula* var. *mesoleptiformis* Krammer。对这些种类在光镜和扫描电镜下的分类学特征进行了详细的描述, 并记录了这些种的生境特点。

**关键词** 羽纹藻属; 新记录; 中国